# PATENT ABSTRACTS OF JAPAN

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(71)Applicant : SHIMADZU CORP
(72)Inventor : SUZUKI MASAYASU

## (54) PLASMA TREATMENT DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide plasma density suitable for a plasma treatment intended to be executed.
SOLUTION: This plasma treatment device is provided with a microwave guide tube 1 with a slot antenna 5 attached to its bottom face; a microwave introduction window 2 for forming a surface wave from the microwave introduced through the slot antenna 5 and transmitting it; an airtight vessel 10 for treating a treatment object by a surface wave-excited plasma; and closing reflectors 6 each having a reflecting surface R facing the outer peripheral side surface 2a of the introduction window 2. By moving the closing reflectors 6, the distance d between the reflecting surface R and the side surface 2a is adjusted.

LEGAL STATUS

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[Number of appeal against examiner's decision of rejection]
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[Date of extinction of right]

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## CLAIMS

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[Claim(s)]
[Claim 1]
Microwave waveguide with which the slot antenna was formed in the base,
The microwave installation aperture which makes a surface wave form and spread from the microwave introduced through said slot antenna,
The tight container which excites process gas by said surface wave, generates the surface wave excitation plasma, and processes a processed material by said surface wave excitation plasma,
Plasma treatment equipment characterized by having the spacing controller material which has the reflector which counters the periphery side face of said microwave installation aperture, and adjusts spacing of said reflector and the periphery side face of said microwave installation aperture.
[Claim 2]
In the plasma treatment equipment of claim 1,
Said microwave installation aperture is making the shape of a rectangle,
Said spacing controller material is plasma treatment equipment characterized by the ability to adjust independently said spacing in four sides of the microwave installation aperture of the shape of said rectangle.

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[Translation done.]

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention]
This invention relates to the plasma treatment equipment using the surface wave excitation plasma.
[0002]
[Description of the Prior Art]
Conventionally, many plasma technics are used for membrane formation, etching processing, ashing processing, etc. in the semi-conductor manufacture process. Moreover, the plasma technic is used also for manufacture of a solar battery, a liquid crystal display, a plasma display, etc. If the high-density and uniform plasma is generated, it will be stabilized in a processed material and uniform processing can be performed.
[0003]
As plasma treatment equipment which can generate the high-density and uniform plasma, the equipment using the surface wave excitation plasma (SWP:Surface Wave Plasma) is known (for example, patent reference 1 reference). This equipment introduces into the plasma production interior of a room the microwave which spreads the inside of a waveguide through a dielectric window (microwave installation aperture) from a slot antenna, by the surface wave produced on the surface of the dielectric window, excites the process gas of the plasma production interior of a room, and generates the surface wave excitation plasma. With conventional plasma treatment equipment, the periphery side face of a dielectric window is surrounded in contact with the wall of a tight container.
[0004]
[Patent reference 1]
JP,2000-348898,A (the 2nd page, drawing 1 )
[0005]
[Problem(s) to be Solved by the Invention]
With this kind of plasma treatment equipment, the magnitude of the surface wave excitation plasma corresponds to the surface wave propagation field on a dielectric window. Moreover, the inside dimension of a tight container is one of the factors which determines the standing wave mode of a surface wave. A plasma consistency and the so-called discharge mode are decided for every standing wave mode of this.
When microwave power and the gas pressure in a tight container are changed, or a type of gas is changed and discharge mode changes, there is a problem that the plasma consistency suitable for the plasma treatment which it is going to carry out is not obtained.
This invention offers the plasma treatment equipment with which a desired plasma consistency is obtained.
[0006]
[Means for Solving the Problem]
The microwave waveguide with which, as for the plasma treatment equipment of claim 1, the slot antenna was formed in the base, The microwave installation aperture which makes a surface

wave form and spread from the microwave introduced through the slot antenna, The tight container which excites process gas by the surface wave, generates the surface wave excitation plasma, and processes a processed material by the surface wave excitation plasma, It has the reflector which counters the periphery side face of a microwave installation aperture, and is characterized by having the spacing controller material which adjusts spacing of a reflector and the periphery side face of a microwave installation aperture.
With above plasma treatment equipment, the microwave installation aperture is making the shape of a rectangle, and, as for spacing controller material, it is desirable for spacing in four sides of a rectangle-like microwave installation aperture to be adjusted independently.
[0007]
[Embodiment of the Invention]
Hereafter, the plasma treatment equipment by this invention is explained with reference to a drawing.
Drawing 1 is the whole block diagram showing typically the plasma treatment equipment by the gestalt of operation of this invention. Drawing 2 is the top view which looked at the chamber inside of the plasma treatment equipment of drawing 1 from the bottom.
The plasma treatment equipment shown in drawing 1 and drawing 2 is equipped with microwave waveguide 1, the dielectric plate 2, and the chamber 10 that consists of the chamber body 3 and a flange 4. A chamber 10 is manufactured from non-magnetic metal ingredients, such as stainless steel, aluminum, and an aluminum alloy.
[0008]
Microwave waveguide 1 is laid in the top face of the dielectric plate 2. Two or more slot antennas 5 which lead microwave to the dielectric plate 2 are formed in bottom plate 1a of microwave waveguide 1.
The dielectric plate 2 is attached in the underside of a flange 4 so that airtight space may be formed in a chamber 10. The dielectric plate 2 is manufactured from dielectric ingredients, such as a quartz, an alumina, a zirconia, and Pyrex glass (trademark of U.S. Corning, Inc.).
[0009]
In drawing 2 , the closing reflectors 6a-6d are attached in the underside of a flange 4 with Bolts 7a-7d so that the dielectric plate 2 may be surrounded. That is, periphery side-face 2a of the rectangle-like dielectric plate 2 is surrounded with four closing reflectors 6a-6d. The spacing d of the closing reflectors [ 6a, 6b, 6c, and 6d ] reflector R and periphery side-face 2a of the dielectric plate 2 is d1, d2, d3, and d4 (it represents with drawing 1 and is written as d by it), respectively.
[0010]
The slots 11a and 11b with a longitudinal direction parallel to the longitudinal direction of space are formed in the closing reflectors 6a and 6b. The closing reflectors 6a and 6b are attached in the non-illustrated flange with the bolts 7a and 7b which penetrate Slots 11a and 11b, respectively. The closing reflectors 6a and 6b are movable by the stroke according to the die length of Slots 11a and 11b, respectively, and can change spacing d1 and d2.
Similarly, the slots 11c and 11d with a longitudinal direction parallel to the vertical direction of space are formed in the closing reflectors 6c and 6d. The closing reflectors 6c and 6d are attached in bolt 7c which penetrates Slots 11c and 11d, respectively, and the flange which is not illustrated [ 7d ]. The closing reflectors 6c and 6d are movable by the stroke according to Slots [ 11c and 11d ] die length, respectively, and can change spacing d3 and d4.
[0011]
What is necessary is to loosen a bolt 7 and just to move the closing reflector 6 along the underside of a flange 4, in order to change spacing d.
The closing reflector 6 is manufactured from non-magnetic metal ingredients, such as stainless steel, aluminum, and an aluminum alloy, as well as a chamber 10.
The closing reflector 6 and a bolt 7 constitute spacing controller material.
[0012]
In drawing 1 , a gas inlet 8 and the evacuation opening 9 are formed in the chamber body 3.
Process gas, such as O2, SiH4, H2, N2, SF6, Cl2, Ar, and helium, is introduced from a gas inlet 8.

By exhausting from the evacuation opening 9, the pressure in a chamber 10 is usually held at about 0.1-50Pa, introducing process gas.
[0013]
Microwave with a frequency of 2.45GHz oscillated from the non-illustrated microwave output section advances the interior of microwave waveguide 1 to the perpendicular direction of space. Microwave passes a slot antenna 5 and it carries out incidence to the dielectric plate 2, and it turns into a surface wave S, spreads the front face by the side of the chamber body 3 of the dielectric plate 2, and spreads all over the dielectric plate 2 in an instant. The propagation field of a surface wave S is almost equal to the area of the front face of the dielectric plate 2.
This surface-wave energy excites the process gas introduced in the chamber 10, and makes Plasma P generate. Although not illustrated, processing of membrane formation, etching, ashing, etc. is performed by placing a processed material into Plasma P.
[0014]
Next, the operation by the closing reflectors 6a-6d is explained with reference to drawing 2 . Microwave M advances the interior of microwave waveguide 1 toward a top from under space. When the closing reflectors 6a-6d do not exist, a surface wave S maintains the standing wave mode decided by the inside dimension of the chamber body 3. That is, the internal surface of the chamber body 3 turns into a reflector, and the location of this reflector determines the standing wave mode of a proper. If the standing wave mode of a surface wave S is decided, the discharge mode (plasma consistency) of the plasma P excited by the surface wave S will also be decided.
[0015]
It is equivalent to changing the inside dimension of the chamber body 3 to change spacing d1-d4 using the closing reflectors 6a-6d of the gestalt of this operation. By this actuation, since the standing wave mode of a surface wave S can be optimized, a desired plasma consistency can be obtained.
Even when parameters, such as microwave power and gas pressure, are specifically changed by changing spacing d1-d4 or a type of gas is changed, it can prevent that the progressive wave of a surface wave S and the reflected wave from the closing reflector 6 negate each other.
[0016]
The spacing d of the reflector R of the closing reflector 6 and periphery side-face 2a of the dielectric plate 2 has the desirable range of 0-lambdas/2, when wavelength of a surface wave S is set to lambdas. For example, in the TE01 mode, since guide wave length lambdag of microwave M is about 147mm, when a quartz (dielectric constant epsilon= 3.6) is used as a dielectric plate, the wavelength lambda of microwave M which spreads the inside of a quartz plate is set to about 77mm. This is called for by lambda=lambda g/epsilon 1/2. If there is lambda / a 2= 38.5mm adjustable range when it is regarded as lambda s**lambda, the standing wave mode of a surface wave S can be optimized.
[0017]
Drawing 3 is the modification of the gestalt of this operation, and is the part plan which looked at the chamber inside of plasma treatment equipment from the bottom. Drawing 3 (a) shows the case where quadrisected closing reflector 6d of drawing 2 , and it considers as the closing reflectors 21-24. The spacing d of the reflector R of the closing reflectors 21-24 and periphery side-face 2a of the dielectric plate 2 changes with closing reflectors rather than is fixed. Drawing 3 (b) shows the case where closing reflector 6d is made to incline at an include angle theta to periphery side-face 2a. This of spacing d is not fixed, either.
Thus, the degree of freedom of the adjustment for obtaining a desired plasma consistency becomes large by making spacing d adjustable by the location.
[0018]
With the gestalt of this operation, although the rectangle-like dielectric plate was used, a circular dielectric plate can also be used. In this case, a closing reflector encloses a dielectric disk and makes it cylindrical. Changing the inside diameter of a cylinder-like closing reflector will change spacing d. It can respond not only to a rectangle but to a circular dielectric plate by preparing two or more cylinder-like closing reflectors with which inside diameters differ, and exchanging them suitably.

[0019]
[Effect of the Invention]
As explained above, according to this invention, the plasma treatment equipment with which a desired plasma consistency is obtained can be offered.
[Brief Description of the Drawings]
[Drawing 1] It is the outline block diagram showing typically the whole plasma treatment equipment concerning the gestalt of operation of this invention.
[Drawing 2] It is the top view which looked at the chamber inside of the plasma treatment equipment concerning the gestalt of operation of this invention from the bottom.
[Drawing 3] It is the modification of the gestalt of operation of this invention, and is the part plan which looked at the chamber inside of plasma treatment equipment from the bottom.
[Description of Notations]
1: Microwave waveguide
2: Dielectric plate (microwave installation aperture)
3: Chamber body
4: Flange
5: Slot antenna
6: Closing reflector
10: Chamber
M: Microwave
S: Surface wave
P: Plasma
R: Reflector

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[Translation done.]

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TECHNICAL FIELD

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[Field of the Invention]
This invention relates to the plasma treatment equipment using the surface wave excitation plasma.
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[Translation done.]

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## PRIOR ART

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[Translation done.]

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## EFFECT OF THE INVENTION

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As explained above, according to this invention, the plasma treatment equipment with which a desired plasma consistency is obtained can be offered.

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## TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]
With this kind of plasma treatment equipment, the magnitude of the surface wave excitation plasma corresponds to the surface wave propagation field on a dielectric window. Moreover, the inside dimension of a tight container is one of the factors which determines the standing wave mode of a surface wave. A plasma consistency and the so-called discharge mode are decided for every standing wave mode of this.
When microwave power and the gas pressure in a tight container are changed, or a type of gas is changed and discharge mode changes, there is a problem that the plasma consistency suitable for the plasma treatment which it is going to carry out is not obtained.
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[Translation done.]

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## MEANS

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[Means for Solving the Problem]
The microwave waveguide with which, as for the plasma treatment equipment of claim 1, the slot antenna was formed in the base, The microwave installation aperture which makes a surface wave form and spread from the microwave introduced through the slot antenna, The tight container which excites process gas by the surface wave, generates the surface wave excitation plasma, and processes a processed material by the surface wave excitation plasma, It has the reflector which counters the periphery side face of a microwave installation aperture, and is characterized by having the spacing controller material which adjusts spacing of a reflector and the periphery side face of a microwave installation aperture.
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[0019]

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] It is the outline block diagram showing typically the whole plasma treatment equipment concerning the gestalt of operation of this invention.
[Drawing 2] It is the top view which looked at the chamber inside of the plasma treatment equipment concerning the gestalt of operation of this invention from the bottom.
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6: Closing reflector
10: Chamber
M: Microwave
S: Surface wave
P: Plasma
R: Reflector

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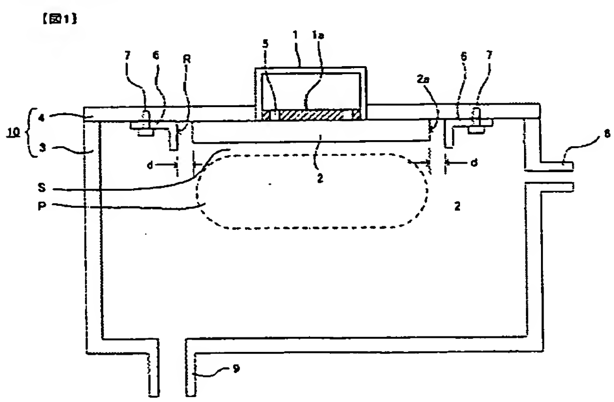
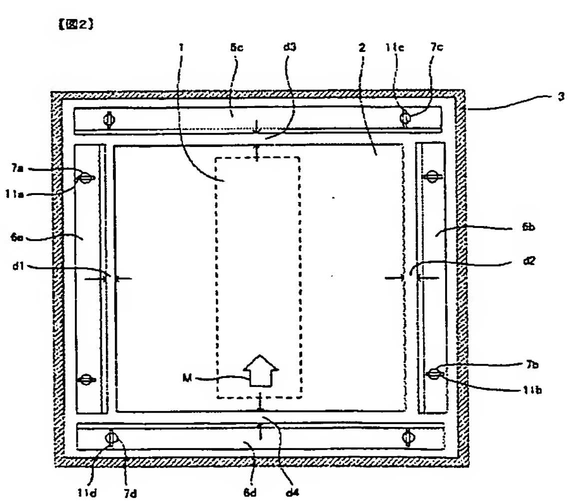
[Translation done.]

## DRAWINGS

[Drawing 1]



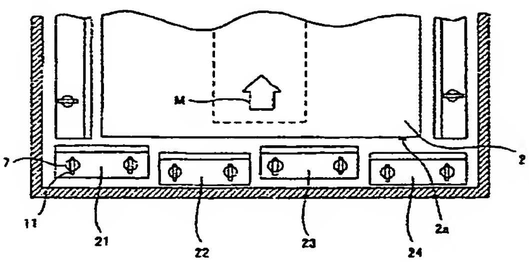

[Drawing 2]




[Drawing 3]

[図3]

(a)

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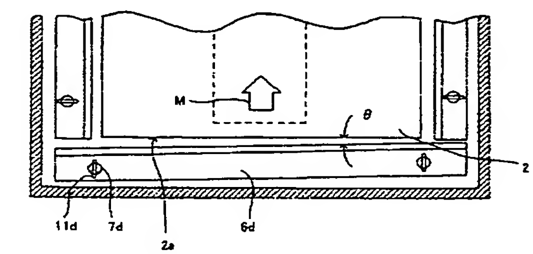


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[Translation done.]

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特開2004-259581
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|---|---|---|---|---|
| H05H 1/46 | H05H 1/46 | | B | 4G075 |
| B01J 19/08 | B01J 19/08 | | E | 5F004 |
| H01L 21/205 | H01L 21/205 | | | 5F045 |
| H01L 21/3065 | H01L 21/302 | 101D | | |

審査請求 未請求　請求項の数 2　OL　（全 6 頁）

(21) 出願番号　特願2003-48753 (P2003-48753)
(22) 出願日　平成15年2月26日 (2003.2.26)

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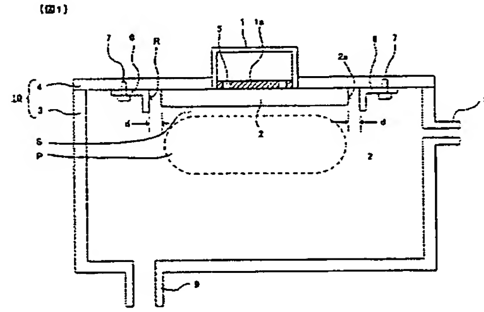
株式会社島津製作所内

Fターム(参考) 4G075 AA24 AA30 BA05 BC06 BC10
CA26 CA47 DA02 EB01 EB33
EC25 EE01
5F004 BA20 BB14 BB18 BC08
5F045 DP04 EB02 EH02 EH03

(54)【発明の名称】プラズマ処理装置

(57)【要約】　（修正有）
【課題】実施しようとするプラズマ処理に適したプラズマ密度が得られる。
【解決手段】底面にスロットアンテナ５が設けられたマイクロ波導波管１と、スロットアンテナ５を通して導入されたマイクロ波から表面波を形成し、伝播させるマイクロ波導入窓２と、表面波励起プラズマより被処理物を処理する気密容器１０と、マイクロ波導入窓２の外周側面２ａに対向する反射面Ｒを有するクローズリフレクター６を設け、クローズリフレクター６を移動させることによって、反射面Ｒと外周側面２ａとの間隔ｄを調整する。
【選択図】　図１

【図1】



【特許請求の範囲】

【請求項１】

底面にスロットアンテナが設けられたマイクロ波導波管と、
前記スロットアンテナを通して導入されたマイクロ波から表面波を形成し、伝播させるマイクロ波導入窓と、
前記表面波によりプロセスガスを励起して表面波励起プラズマを生成し、前記表面波励起プラズマにより被処理物を処理する気密容器と、
前記マイクロ波導入窓の外周側面に対向する反射面を有し、前記反射面と前記マイクロ波導入窓の外周側面との間隔を調整する間隔調整部材とを備えたことを特徴とするプラズマ処理装置。

【請求項２】

請求項１のプラズマ処理装置において、
前記マイクロ波導入窓は矩形状をなしており、
前記間隔調整部材は、前記矩形状のマイクロ波導入窓の４辺における前記間隔を独立に調整可能であることを特徴とするプラズマ処理装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】

本発明は、表面波励起プラズマを利用したプラズマ処理装置に関するものである。

【０００２】

【従来の技術】

従来、半導体製造プロセスでは、成膜、エッチング処理、アッシング処理等にプラズマ技術が多く利用されている。また、太陽電池、液晶ディスプレイ、プラズマディスプレイ等の製造にもプラズマ技術が利用されている。高密度で均一なプラズマを生成すれば、被処理物に安定して均一な処理ができる。

【０００３】

高密度で均一なプラズマを生成できるプラズマ処理装置としては、表面波励起プラズマ（ＳＷＰ：Ｓｕｒｆａｃｅ Ｗａｖｅ Ｐｌａｓｍａ）を利用する装置が知られている（例えば、特許文献１参照）。この装置は、導波管内を伝播するマイクロ波をスロットアンテナから誘電体窓（マイクロ波導入窓）を通してプラズマ生成室内に導入し、誘電体窓の表面に生じた表面波によってプラズマ生成室内のプロセスガスを励起し、表面波励起プラズマを生成するものである。従来のプラズマ処理装置では、誘電体窓の外周側面は、気密容器の内壁に接して取り囲まれている。

【０００４】

【特許文献１】

特開２０００－３４８８９８号公報（第２頁、図１）

【０００５】

【発明が解決しようとする課題】

この種のプラズマ処理装置では、表面波励起プラズマの大きさは、誘電体窓上の表面波伝播領域に対応する。また、気密容器の内側寸法は、表面波の定在波モードを決める因子の一つである。この定在波モード毎にプラズマ密度、いわゆる放電モードが決まる。
マイクロ波電力や気密容器内のガス圧力を変化させたり、ガス種を変えたときに、放電モードが変化してしまうと、実施しようとするプラズマ処理に適したプラズマ密度が得られないという問題がある。
本発明は、所望のプラズマ密度が得られるプラズマ処理装置を提供するものである。

【０００６】

【課題を解決するための手段】

請求項１のプラズマ処理装置は、底面にスロットアンテナが設けられたマイクロ波導波管と、スロットアンテナを通して導入されたマイクロ波から表面波を形成し、伝播させるマイクロ波導入窓と、表面波によりプロセスガスを励起して表面波励起プラズマを生成し、

表面波励起プラズマにより被処理物を処理する気密容器と、マイクロ波導入窓の外周側面に対向する反射面を有し、反射面とマイクロ波導入窓の外周側面との間隔を調整する間隔調整部材とを備えたことを特徴とする。
上記のプラズマ処理装置では、マイクロ波導入窓は矩形状をなしており、間隔調整部材は、矩形状のマイクロ波導入窓の４辺における間隔を独立に調整可能であることが好ましい。

【０００７】
【発明の実施の形態】
以下、本発明によるプラズマ処理装置について、図面を参照して説明する。
図１は、本発明の実施の形態によるプラズマ処理装置を模式的に示す全体構成図である。
図２は、図１のプラズマ処理装置のチャンバー内側を下から見た平面図である。
図１および図２に示されるプラズマ処理装置は、マイクロ波導波管１と、誘電体板２と、チャンバー本体３およびフランジ４から成るチャンバー１０とを備える。チャンバー１０は、ステンレス鋼、アルミニウム、アルミニウム合金等の非磁性金属材料から製作される。

【０００８】
マイクロ波導波管１は、誘電体板２の上面に載置されている。マイクロ波導波管１の底板１ａには、マイクロ波を誘電体板２へ導くスロットアンテナ５が複数個形成されている。
誘電体板２は、チャンバー１０内に気密空間を形成するように、フランジ４の下面に取り付けられている。誘電体板２は、石英、アルミナ、ジルコニア、パイレックスガラス（米国コーニング社の登録商標）等の誘電性材料から製作される。

【０００９】
図２において、クローズリフレクター６ａ～６ｄは、誘電体板２を取り囲むように、フランジ４の下面にボルト７ａ～７ｄで取り付けられている。すなわち、矩形状の誘電体板２の外周側面２ａは、４個のクローズリフレクター６ａ～６ｄで取り囲まれている。クローズリフレクター６ａ、６ｂ、６ｃおよび６ｄの反射面Ｒと誘電体板２の外周側面２ａとの間隔ｄは、それぞれｄ１、ｄ２、ｄ３およびｄ４（図１では、代表してｄと表記する）である。

【００１０】
クローズリフレクター６ａ、６ｂには、長手方向が紙面の左右方向に平行な長穴１１ａ、１１ｂが設けられている。クローズリフレクター６ａ、６ｂは、それぞれ長穴１１ａ、１１ｂを貫通するボルト７ａ、７ｂで不図示のフランジに取り付けられている。クローズリフレクター６ａ、６ｂは、それぞれ長穴１１ａ、１１ｂの長さに応じたストロークで移動でき、間隔ｄ１、ｄ２を変化させることができる。
同様に、クローズリフレクター６ｃ、６ｄには、長手方向が紙面の上下方向に平行な長穴１１ｃ、１１ｄが設けられている。クローズリフレクター６ｃ、６ｄは、それぞれ長穴１１ｃ、１１ｄを貫通するボルト７ｃ、７ｄで不図示のフランジに取り付けられている。クローズリフレクター６ｃ、６ｄは、それぞれ長穴１１ｃ、１１ｄの長さに応じたストロークで移動でき、間隔ｄ３、ｄ４を変化させることができる。

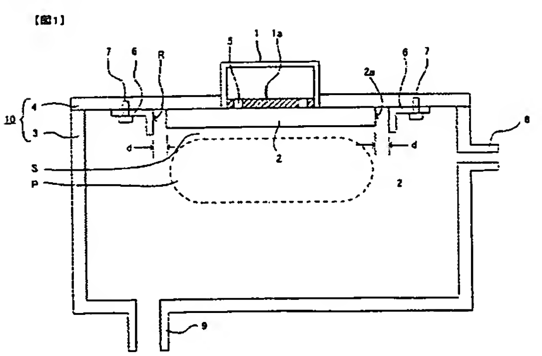
【００１１】
間隔ｄを変化させるには、ボルト７を緩めて、クローズリフレクター６をフランジ４の下面に沿って移動させればよい。
クローズリフレクター６は、チャンバー１０と同じく、ステンレス鋼、アルミニウム、アルミニウム合金等の非磁性金属材料から製作される。
クローズリフレクター６とボルト７が間隔調整部材を構成する。

【００１２】
図１において、チャンバー本体３には、ガス導入口８と真空排気口９が設けられている。ガス導入口８から$O_2$，$SiH_4$，$H_2$，$N_2$，$SF_6$，$Cl_2$，Ａｒ，Ｈｅ等のプロセスガスが導入される。プロセスガスを導入しながら真空排気口９から排気することによって、チャンバー１０内の圧力は通常、０．１～５０Ｐａ程度に保持される。

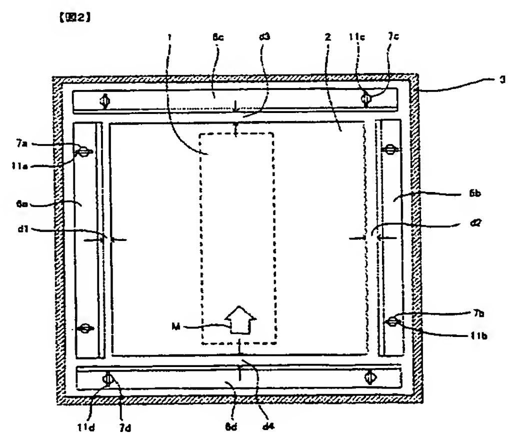
【００１３】
不図示のマイクロ波出力部から発振された例えば周波数２．４５ＧＨｚのマイクロ波は、マイクロ波導波管１の内部を紙面の垂直方向に進行する。マイクロ波は、スロットアンテナ５を通過して誘電体板２に入射し、表面波Ｓとなって誘電体板２のチャンバー本体３側の表面を伝播し、瞬時に誘電体板２の全面に拡がる。表面波Ｓの伝播領域は、誘電体板２の表面の面積にほぼ等しい。
この表面波エネルギーは、チャンバー１０内に導入されているプロセスガスを励起してプラズマＰを生成させる。図示されていないが、プラズマＰ中に被処理物を置くことによって、成膜、エッチング、アッシング等の処理が行われる。
【００１４】
次に、クローズリフレクター６ａ～６ｄによる作用を図２を参照して説明する。
マイクロ波Ｍは、マイクロ波導波管１の内部を紙面の下から上に向かって進行する。
クローズリフレクター６ａ～６ｄが存在しないときは、表面波Ｓは、チャンバー本体３の内側寸法で決まる定在波モードを維持する。すなわち、チャンバー本体３の内壁面が反射面となり、この反射面の位置が固有の定在波モードを決めるのである。表面波Ｓの定在波モードが決まれば、表面波Ｓで励起されたプラズマＰの放電モード（プラズマ密度）も決まる。
【００１５】
本実施の形態のクローズリフレクター６ａ～６ｄを用いて間隔ｄ１～ｄ４を変えることは、チャンバー本体３の内側寸法を変えることに相当する。この操作によって、表面波Ｓの定在波モードを最適化することができるので、所望のプラズマ密度を得ることができる。
具体的には、間隔ｄ１～ｄ４を変更することによって、マイクロ波電力やガス圧力等のパラメータを変化させたり、ガス種を変えたときでも、表面波Ｓの進行波とクローズリフレクター６からの反射波とが打ち消し合うことを防止することができる。
【００１６】
クローズリフレクター６の反射面Ｒと誘電体板２の外周側面２ａとの間隔ｄは、表面波Ｓの波長をλｓとすると、０～λｓ／２の範囲が望ましい。例えば、ＴＥ０１モードでは、マイクロ波Ｍの管内波長λｇは１４７ｍｍ程度であるから、石英（誘電率$\varepsilon$＝３．６）を誘電体板として用いた場合、石英板内を伝播するマイクロ波Ｍの波長λは７７ｍｍ程度となる。これは、$\lambda = \lambda g / \varepsilon^{1/2}$により求められる。λｓ≒λと看做すと、λ／２＝３８．５ｍｍの調整範囲があれば、表面波Ｓの定在波モードを最適化することができる。
【００１７】
図３は、本実施の形態の変形例であり、プラズマ処理装置のチャンバー内側を下から見た部分平面図である。図３（ａ）は、図２のクローズリフレクター６ｄを４分割してクローズリフレクター２１～２４とした場合を示す。クローズリフレクター２１～２４の反射面Ｒと誘電体板２の外周側面２ａとの間隔ｄは、一定ではなく、クローズリフレクターによって異なっている。図３（ｂ）は、クローズリフレクター６ｄを外周側面２ａに対して角度θで傾斜させた場合を示す。これも間隔ｄは一定ではない。
このように、間隔ｄを場所によって可変とすることによって、所望のプラズマ密度を得るための調整の自由度が大きくなる。
【００１８】
本実施の形態では、矩形状の誘電体板を用いたが、円形の誘電体板を用いることもできる。この場合、クローズリフレクターは、誘電体円板を取り囲む円筒状とする。円筒状のクローズリフレクターの内径寸法を変えることは、間隔ｄを変えることになる。内径寸法の異なる円筒状のクローズリフレクターを複数個用意し、適宜交換することによって、矩形だけではなく円形の誘電体板にも対応できる。
【００１９】
【発明の効果】
以上説明したように、本発明によれば、所望のプラズマ密度が得られるプラズマ処理装置を提供することができる。

【図面の簡単な説明】
【図１】本発明の実施の形態に係るプラズマ処理装置全体を模式的に示す概略構成図である。
【図２】本発明の実施の形態に係るプラズマ処理装置のチャンバー内側を下から見た平面図である。
【図３】本発明の実施の形態の変形例であり、プラズマ処理装置のチャンバー内側を下から見た部分平面図である。
【符号の説明】
１：マイクロ波導波管
２：誘電体板（マイクロ波導入窓）
３：チャンバー本体
４：フランジ
５：スロットアンテナ
６：クローズリフレクター
１０：チャンバー
Ｍ：マイクロ波
Ｓ：表面波
Ｐ：プラズマ
Ｒ：反射面

【図１】



【図２】



【図３】